Q54152AP.SPP
April 24, 2000

COLOR IMAGE SEGMENTATION METHOD

This is a non-provisional application claiming benefit of provisional application 60/130,643 filed on April 23, 1999.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a color image segmentation method, and more particularly, to a color image segmentation method for segmenting a color image.

2. Description of the Related Art

The segmentation of a color image is a very important part of digital image processing and its applications. A first type of conventional color image segmentation method has a problem in that it is not easy to segment a color image containing texture. A second type of conventional color image segmentation method for performing an automatic segmentation does not perform well when used to process an input image containing noise. A third type of conventional color image segmentation method requires a user to prepare the image by manual segmentation. Though this third method produces satisfactory results even with respect to an input image containing noise, an automatic segmentation is not performed, therefore, this third method requires significant processing time.

SUMMARY OF THE INVENTION

To solve the above problems, it is an object of the present invention to provide a color image segmentation method capable of automatically segmenting a color image containing texture and performing well even with respect to an input image containing noise.

It is another object of the present invention is to provide a color image processing method containing the color image segmentation method.

It is still another object of the present invention is to provide a medium in which a computer program performing the color image segmentation method is stored.

Accordingly, to achieve the above objects, according to one aspect of the present invention, there is provided a color image segmentation method. The color image segmentation method comprises the steps of: (a) calculating a first value representing a degree of difference between the color of a pixel and peripheral pixels based on a plurality of pixel values of an input image; (b) obtaining a converted image by converting the first value into a value of a predetermined scale; and (c) segmenting the converted image.

Preferably, the step (c) segments the converted image based on a region growing method.

It is preferable that the color image segmentation method, prior to the step (a), further comprises the step of (p-a) quantizing pixel values of an image into a predetermined number of representative pixel values; wherein the pixel values are quantized pixel values.

The representative pixel values preferably consist of 10-20 values.

It is preferable that the color image segmentation method, prior to the step (a), further comprises the steps of: (p-a-1) defining a window containing a center pixel; and (p-a-2) calculating the first value representing the degree of difference from the color of peripheral pixels with respect to pixels in the defined window.

It is also preferable that the step (a) comprises the steps of: (a-1) defining a window B which is centered at a pixel p and has a size of d x d where d is a positive integer preferably between 3 and 10, inclusive; and (a-2) classifying a pixel position z into a C number of classes when i is a number between 1 and C, and Z is a set of all pixels in the window B; and (a-3) obtaining a J-value with respect to each pixel in a class-map as:

$$J = \frac{S_B}{S_W} = \frac{S_T - S_W}{S_W}$$

where m_i is the average of positions of N_i data points in class Z_i,

$$S_T = \sum_{z \in Z} \left\| z - m \right\|^2 \text{ and } S_W = \sum_{i=1}^{C} S_i = \sum_{i=1}^{C} \sum_{z \in Z_i} \left\| z - m_i \right\|^2$$

The predetermined scale is preferably a gray scale having values between 0 and 255.

In order to achieve the above object, according to another aspect of the present invention, there is provided a color image segmentation method. The color image segmentation method comprises the steps of: (a) quantizing pixel values of an image into a predetermined number of representative pixel values; (b) calculating a value representing a degree of difference between the color of pixels in a predetermined size window using quantized representative pixel values; (c) obtaining a converted image by converting the calculated value into a value of a predetermined scale; and (d) segmenting the converted image using a segmentation method based on a region growing method.

In order to achieve another object, there is provided an object-based color image processing method for processing a color image according to a color image segmentation method. The color image segmentation method comprises the steps of: (a) calculating a predetermined value representing a degree of difference between a pixel and the color of peripheral pixels based on a plurality pixel values of an input image; (b) obtaining a converted image by converting a calculated value into a value of a predetermined scale; and (c) segmenting the converted image.

In order to achieve still another object, there is provided a medium for storing program codes performing a color image segmentation method for segmenting a color image into a plurality of regions. The medium includes computer readable program means for: (a) quantizing pixel values of an image into a predetermined number of representative pixel values; (b) calculating a value representing a degree of difference between the color of pixels

in a predetermined size window using quantized representative pixel values; (c) obtaining a converted image by converting a calculated value into a value of a predetermined scale; and (d) segmenting the converted image using a segmentation method based on a region growing method.

BRIEF DESCRIPTION OF THE DRAWINGS

The above objects and advantages of the present invention will become more apparent by describing in detail preferred embodiments thereof with reference to the attached drawings in which:

FIG. 1 is a flowchart illustrating a color image segmentation method according to a preferred embodiment of the present invention;

FIGS. 2A through 2C illustrate class-maps and J-values formed according to a color image segmentation method of FIG. 1;

FIGS. 3A and 3B illustrate segmented class-maps;

FIG. 4A illustrates one image frame of a "container" as a test image and a test image segmented by the color image segmentation method according to the present invention;

FIG. 4B illustrates one image frame of a "foreman" as a test image and a test image segmented by the color image segmentation method according to the present invention;

FIG. 4C illustrates one image frame of a "coast" as a test image and a test image segmented by the color image segmentation method according to the present invention;

FIG. 4D illustrates one image frame of a "flower garden" as a test image and a test image segmented by the color image segmentation method according to the present invention; and

FIG. 4E illustrates one image frame of a "mother and daughter" as a test image and a test image segmented by the color image segmentation method according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1, which illustrates a flowchart illustrating a color image segmentation method according to a preferred embodiment of the present invention, a color image is input (step 102), and pixel values of an input image are quantized into several representative pixel values (step 104). In order to classify an image in natural scenes, the representative pixel values consist of 10-20 quantized values. In this embodiment, quantization is performed using three representative pixel values for convenience of explanation. Next, a class-map is formed by assigning labels corresponding to quantized representative pixel values (step 106).

More preferably, a window centered at a pixel to be processed in an entire image is defined. That is, when d is a positive integer, preferably between 3 and 10 (inclusive), a window B which is centered at a pixel p or at approximately pixel p and has a size of d x d, is defined. Also, an assumption is made that i is a number between 1 and C, and Z is a set of all the pixels in the window B. An assumption is made that Z is classified into a C number of classes. In other words, Z is classified into C classes Z_i, i=1...C.

Also, an assumption is made that a specific class variable m_i is the average of positions of N_i data points in class Z_i as:

(equation 1)

$$m_i = \frac{1}{N_i} \sum_{z \in Z_i} z$$

The more general counterpart of m_i may be represented by m.

Also, S_T and S_W are defined by:

(equation 2)

$$S_T = \sum_{z \in Z} \|z - m\|^2 \text{ and}$$

(equation 3)

$$S_W = \sum_{i=1}^{C} S_i = \sum_{i=1}^{C} \sum_{z \in Z_i} \|z - m_i\|^2$$

respectively.

Next, a J-value with respect to each pixel in a class-map is obtained (step 108). The J-value with respect to each pixel in the class-map is defined as follows:

(equation 4)

$$J = \frac{S_B}{S_W} = \frac{S_T - S_W}{S_W}$$

The J-values obtained by equation 4 are converted into a gray scale value between 0 and 255, so that a gray scale image having values and capable of being referred to as a J-image is obtained (step 110). The J-image has the same form as a three-dimensional topographic map containing valleys and mountains that actually represent region centers and region boundaries, respectively.

Lastly, the J-image is segmented based on a region growing method (step 112). The region growing method is known to one of ordinary skill in the art as a method used for the segmentation of a digital image, therefore, an explanation thereof is not given.

FIGS. 2A through 2C illustrate class-maps and J-values formed according to a color image segmentation method of FIG. 1. The J-value at the center pixel is 1.720 in the class-map of FIG. 2A, and in the class-map of FIG. 2B, the J-value at the center pixel is 0, and in the class-map of FIG. 2C, the J-value at the center pixel is obtained as 0.855. In the class-map of FIG. 2A, in the case where pixels represented as + are located at the left of the center pixel, pixels represented as 0 are located at the right and upper portions relative to the center pixel, and pixels represented as * are located to the bottom lower portions relative to the center pixel, the pixels form regions most clearly. Here, the J-value is 1.720, a relative large

value. By contrast, in the class-map of FIG. 2B, in the case where the pixels represented as +, the pixels represented as 0, and the pixels represented as * are uniformly distributed and do not readily form regions, the J-value is 0. Furthermore, in the class-map of FIG. 2C, in the case where the pixels represented as + are located at the left of the center pixel form regions, but the pixels represented as 0 and * to the right of the center pixel do not readily form regions, the J-value is 0.855. As is apparent from the previous discussion, the larger the J-value at the center pixel, the more likely that the pixel is near a region boundary. Therefore, a segmentation based on the region growing method by using this point can be performed.

FIGS. 3A and 3B illustrate segmented class-maps.

It is necessary to check whether segmentation has been performed well with respect to each region in the segmented class-maps and to represent the same as quantized values. For this purpose, when J_k is the J-value obtained with respect to a k-region, and M_k is the number of pixel points of a k-th region, and N is the total number of pixel points in the class-map, the averaged J-value is calculated as:

(equation 5)

$$\bar{J} = \frac{1}{N}\sum_k M_k J_k$$

The calculated values are represented as quantized values representative of whether a segmentation is performed well with respect to each region in the segmented class-maps or not.

5,6 A17

In the case of the segmented class-map shown in FIG. 3A, J is 0, on the other hand, in the case of the segmented class-map shown in FIG. 3B, J is 0.05. That is, in the case of regions of a fixed number, especially in the case of better segmentation, the averaged J-value

is small. This occurs because the region contains a few uniformly distributed color classes in the case where a region is well segmented. Accordingly, the averaged J-value is small.

FIG. 4A illustrates one image frame of a "container" as a test image and a test image segmented by the color image segmentation method according to the present invention. Referring to FIG. 4A, $\bar{J}$ of an image before segmentation is 0.232, but, $\bar{J}$ of the image after segmentation is 0.071. Also, it is evident that regions in the test image are well segmented.

FIG. 4B illustrates one image frame of a "foreman" as a test image and a test image segmented by the color image segmentation method according to the present invention. Referring to FIG. 4B, $\bar{J}$ of an image before segmentation is 0.238, but $\bar{J}$ of the image after segmentation is 0.105. Also, it is evident that regions in the test image are well segmented.

FIG. 4C illustrates one image frame of a "coast" as a test image and a test image segmented by the color image segmentation method according to the present invention. Referring to FIG. 4C, $\bar{J}$ of an image before segmentation is 0.494, but $\bar{J}$ of the image after segmentation is 0.093. Also, it is evident that regions in the test image are well segmented.

FIG. 4D illustrates one image frame of a "flower garden" as a test image and a test image segmented by the color image segmentation method according to the present invention. Referring to FIG. 4D, $\bar{J}$ of an image before segmentation is 0.435, but $\bar{J}$ of the image after segmentation is 0.088. Also, it is evident that regions in the test image are well segmented.

FIG. 4E illustrates one image frame of a "mother and daughter" as a test image and a test image segmented by the color image segmentation method according to the present invention. Referring to FIG. 4E, $\bar{J}$ of an image before segmentation is 0.438, but $\bar{J}$ of the image after segmentation is 0.061. Also, it is evident that regions in the test image are well segmented.

That is, as described referring to FIG. 4A through 4E, $\bar{J}$ of the image segmented by the color image segmentation method according to the present invention is smaller than $\bar{J}$ of the image before segmentation.

In the above color image segmentation method according to the present invention, a robust segmentation is possible even when segmenting an image containing much noise or texture. Furthermore, an automatic segmentation is possible without user's assistance, such as segmentation performed manually by a user. Therefore, the segmentation can be performed rapidly. The color image segmentation method can be applied to object-based image processing such as that used in MPEG-7.

In the above embodiment, the calculation of specific functions are explained as examples, however, this is only for purposes of explanation. The scope of the present invention defined in the appended claims is not limited to the embodiment, and it is obvious that one of ordinary skill in the art can use another modified function representing the degree of difference from the color of peripheral pixels.

For instance, in equation 3, S_W may be represented by

$$S_W = \sum_{i=1}^{C} Si = \sum_{z \in Z_i} \left\| z - m_i \right\|^2$$

Furthermore, the above color image segmentation method can be embodied in a computer program. Codes and code segments comprising the program can be easily inferred by a skilled computer programmer in the art. Also, the program can be stored in computer readable media, read and executed by a computer, and it can thereby realize the color image processing method. The media can include magnetic media, optical media, and carrier waves, or other media used for machine-readable forms.

As described above, according to the present invention, a color image can be automatically segmented without a user's assistance and is robust and effective even with respect to an input image containing noise.